PATENT SPECIFICATION

(11) 1 285 381

1 285 381

DRAWINGS ATTACHED

(21) Application No. 16874/70 (22) Filed 9 April 1970

(45) Complete Specification published 16 Aug. 1972

(51) International Classification D01D 5/08 // D04H 3/12

(52) Index at acceptance

B5B 352 35Y 360 401 409 510 540 660 801

D1R 3B1 3C2B 3C2C 3C2G 3C2Y 3C5A 3C5X 3D1AY 3D2A 3D3B 3D3C 3D3E

(72) Inventors SHUNSUKE FUKADA and TORU NAKANISHI

(54) PROCESS FOR THE MANUFACTURE OF CONTINUOUS FILAMENTS

(71) We, TORAY INDUSTRIES INC., a body corporate organised and existing under the laws of Japan, of 2, Nihonbashi-Muromachi 2-chome, Chuo-ku, Tokyo, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a process for manufacturing continuous filaments from synthetic polymer melts for use in non-woven products.

The invention provides a process for the manufacture of continuous filaments from a synthetic polymer melt comprising hot-melt extruding the polymer into a pressurized chamber and introducing a pressurized fluid into the chamber for cooling and solidifying the filaments and for ejecting them from the chamber through an exit nozzle; the rate of extrusion per filament being

$$1.5L+0.05 \leqslant M \leqslant 5.5L+2.25$$
$$L \geqslant 0.30$$

wherein L is the distance between the spinneret orifices and the exit nozzle in meters and M is the extrusion rate of the polymer per spinneret orifice in grams per minute.

Preferably the length L_2 of the flow passage of the exit nozzle is at least 20 mm. Ejector apparatus for performing the process of the invention conveniently comprises an ejector comprising a hot-melt extruder leading into a pressurized chamber having a distributor for the introduction of pressurized fluid for cooling and solidifying the filaments and ejecting them through one or more exit nozzles in the chamber, the nozzle or nozzles being movable relative to the chamber. Preferably the exit nozzle or nozzles have a spherical outer form and are rotatably mounted in a spherical seat whereby the direction of the nozzle or nozzles may be adjusted.

Suitably the exit nozzle or nozzles have a cylindrical outer form and are rotatably mounted, the axis of the nozzle or nozzles being oblique to the axis of rotation, whereby the direction of the nozzle or nozzles may be adjusted, and a flexible tube is secured to the outer end of the exit nozzle or nozzles.

It has been found that the invention makes it possible to obtain a high degree of orientation in the filaments produced and thus homogeneous non-woven products even from large denier continuous filaments. The fluid also serves to draw the filaments and thus to improve their properties.

In the process of the invention a force of a jet stream is introduced into the pressurized chamber and serves to advance the filaments. The forces acting on the filament in the chamber depend only on the pressure which can be accurately controlled. The forces are not likely to be affected by external forces such as the atmospheric pressure. Thus it is possible to exert a strong force on the filaments being processed. It is possible to obtain bundles of relatively large denier filaments which are highly oriented. Bundles of highly oriented small denier filaments can also be obtained using a small amount of compressed fluid.

The process of the invention is especially useful in preparing non-wovens from synthetic linear polymers of the polyester series.

The position of the orifices through which the compressed fluid is introduced into the chamber should generally be at least half the distance from the spinneret orifices to the exit nozzle in order to reduce the elongation of the filaments. Most preferably, the location of the compressed fluid exit orifices is at a point in the lower portion of the chamber which is immediately adjacent the exit nozzle. When it is desired to have the final filaments in a more separated condition for use in the manufacture of non-woven products, it is preferable to form the ejector with a plurality of exit nozzles in the lower end of

the chamber. The filaments from the spinneret are then fed into the separate exit nozzles and the product is ejected in a more divided condition.

The filaments may be given heat shrinking properties obtained by immersing the filaments in boiling water. When the filaments are immersed in boiling water for 15 minutes without tension, and the shrinkage which results is not more than 15%, flow problems are encountered using such filaments. As a criterion for judging the quality of high orientability, it is advisable to use the elongation at break of the filaments. If the elongation at break is not more than about 100%, the filaments are suitable for use in non-woven sheets having a weight of not less than 50 g/m^2.

Synthetic polymers having fibre-forming properties can be used according to the invention. Representative polymers are for example, polyesters, for example, polyethylene terephthalate and polycyclohexanedimethanol terephthalate, polyamides, for example, nylon 6, nylon 66, nylon 8 and nylon 12 and polyolefins, for example, polypropylene and polyethylene.

Non-woven sheet is in general a structure which consists of continuous filaments, made of a synthetic linear fibre-forming polymer, more or less randomly positioned with a greater part of the individual filaments in the sheet being separated from one another. The filaments made by the process of the invention can be processed further into non-woven sheets by heating to fusion point or being treated with an adhesive. They are useful in the manufacture of for example, clothing, padding, carpeting, curtains or interior decorations.

The invention is illustrated by way of example in the drawings in which:

Figure 1 is a partial section of a prior art filament ejector;

Figure 2 is a partial section of a filament ejector for performing the process according to the invention;

Figure 3 is a section of an ejector similar to that of Figure 2;

Figure 4 is a section of apparatus for performing the process according to the invention and for preparing non-woven materials;

Figure 5 is a section of another filament ejector for performing the process according to the invention;

Figure 6 is a graph showing the relationship of the rate of extrusion M (g/min.) of a synthetic linear polymer per orifice of the spinneret against the distance L (metres) between the spinneret plate and the exit nozzle;

Figure 7 is a section of another filament ejector for performing the process according to the invention;

Figure 8 is a section of a further filament ejector for performing the process according to the invention;

Figure 9 is a plan of various spinneret plates and exit nozzle plates of the ejector of Figure 8;

Figures 10 and 11 are partial sections of further ejectors according to the invention;

Figure 12 shows the preparation of a non-woven sheet using a number of the ejectors of Figure 10; and

Figure 13 is a partial section of a further ejector for performing the process according to the invention.

In Figure 1, a synthetic linear polymer filament 10 is extruded from a spinneret 12 and cooled and solidified until it reaches an ejector 14. It is then pulled by a compressed air stream 16 blown into the ejector 14 and discharged from the lower end of the ejector. Uncompressed air enters the upper open end of the ejector as shown by arrows 18. This uncompressed air stream shown by the arrows 18 reduces the energy of the compressed air stream 16. In order to increase the degree of orientation of the filaments 20, the energy of the compressed air stream 16 must be increased to compensate for the loss of energy. The critical balance of the dimensions of the lower open end of the ejector 14 can be disrupted by the increased amount of compressed air and thus cause the compressed air stream 16 to blow out of the upper end opening and distort the alignment of the filaments. Accordingly there is an upper limit to the degree of orientation of the filaments which can be obtained. There is also an upper limit to the deniers of the filaments which can be treated. When the size of the filament exceeds 6 denier it becomes difficult to obtain highly oriented filaments.

In an ejector as shown in Figure 2 filaments 20 are spun from a spinneret 22 directly into a sealed pressure chamber 24 and are cooled inside the chamber 24 by compressed fluid 26. The filaments 20 are ejected from the chamber 24 together with the compressed fluid 26 through the exit nozzle 28 provided at the lower end of the pressure chamber 24. Large denier filaments may be oriented using this ejector.

In Figure 3 the lower end of the spinneret assembly 30 and the upper end of a cylinder 32 are connected together in a gas tight fit. On the lower end surface of the spinneret assembly 30 there is mounted a spinneret plate 34 which contains a number of spinneret orifices 36. On the peripheral surface of the lower end of the cylinder 32, there is an annular compressed air distribution chamber 38. The compressed air distribution chamber 38 and the inside of the cylinder 32 are connected through small holes 40 in the lower end of the cylinder 32. On the lower end of the cylinder 32, an exit nozzle plate 42

is mounted in a gas tight fit. At the centre of the exit nozzle plate 42, an exit nozzle 44 connects the inside of the cylinder 32 with the outside. A compressed air supply pipe 46 is connected to the compressed air distribution chamber through which compressed air is supplied. The compressed air is introduced into the cylinder 32 through the small holes 40 via the compressed air distribution chamber 38 to form a pressure chamber 48. From the pressure chamber 48, the compressed air is ejected via the nozzle 44 so that the pressure in the chamber is constant. In the apparatus of Figure 3, a fibre forming melt 50 is extruded from the spinneret orifices 36 to form filaments 52. The extruded filaments pass through the pressure chamber 48 where they are cooled and solidified by the compressed fluid and ejected together with a portion of the compressed fluid through the nozzle 44. During this period the filaments 52 are oriented. The filaments, as they are ejected from the pressure chamber, are caught and collected to form a non-woven sheet.

A distance of 10 mm between the inner wall surface of the cylinder 32 and the spun bundle of filaments 52 is sufficient but it can be considerably larger, for example 100 mm. The distance between the lower open end surface of the spinneret plate 34 and the upper end surface of the nozzle plate 42 is sufficient for the bundle of filaments 52 to be solidified so that the individual filaments will not adhere to each other as the bundle passes through the exit nozzle 44. If this length is too short, the bundle of filaments will stick together and will be ejected from the nozzle 44 as a fused body. Accordingly, it is necessary to select the minimum distance between the spinneret orifices 36 and the nozzle 44 taking into account the melting point of the fibre forming fluid, the rate of extrusion of the melted polymer and the temperature and the pressure of the compressed air. This is especially important when polymers having relatively low melting points such as polyethylene and polypropylene are used. Longer distances and compressed air at a lower temperature become necessary with these materials. On the other hand, in the case of polyethylene terephthalates which have relatively high melting points the process may be practised with a distance between the spinneret orifices and exit nozzle of less than 500 mm. and with the compressed air at room temperature. When the rate of extrusion is increased, the filaments 52 are cooled less efficiently and the distance between the spinneret plate and the exit nozzles should accordingly be increased. In such cases, the wall of the pressure chamber 48 may be gradually cooled or a part of the compressed air may be fed into an upper part of the chamber 48 by another pipe (not shown). Generally the degree of orientation of the filaments 52 ejected from the exit nozzle 44 increases with higher pressure of the compressed fluid supplied to the pressure chamber.

In Figure 4 a synthetic polymer 54 is supplied to a hopper 56 in the form of chips. The chips from the hopper 56 are gradually fed by a screw to a heater assembly 58 in which the chips are melted. The molten polymer is fed to a spinning assembly via a measuring pump and extruded through a number of spinneret orifices 64 as continuous filaments. These filaments 66 contact a compressed fluid inside the pressure chamber within a cylinder 70 and are cooled until the filaments 66 do not adhere to each other. The filaments 66 are then ejected from the pressure chamber together with the compressed fluid through an exit nozzle 72. The ejected filaments 74 are highly oriented. The filaments 74 fall on to a moving wire mesh conveyor 76. The filaments 74 are collected in a random manner on the wire conveyor 75 to form the non-woven sheet. The layer of filaments 78 is pressed on both sides by a pair of press rollers and subjected to a heat setting treatment to dimensionally stabilize the sheet. The ejected filaments do not shrink at low temperatures and are highly oriented. The breaking of the filaments during formation of a non-woven sheet is not desired as it reduces production efficiency.

A high degree of orientation of the filaments is obtainable using the ejector of Figure 5. Figure 5 is very similar to Figure 3 so corresponding parts are similarly numbered. The most important difference is that in Figure 5 the length of the exit nozzle 80 is substantially longer than the corresponding nozzle 44 of Figure 3. When the length L, of the flow passage of the exit nozzle 80 is at least 20 mm. it is possible to advance the ejection speed of the filaments by from 1,000 to 2,000 m/min. Increase of the spinning speed naturally accompanies an increase in output. There is improved drawing of the filaments which makes the denier of the filaments and the properties of the final non-woven sheet more uniform. Also compressed fluid requirements are reduced.

The diameter of the exit nozzle 80 should be selected taking into account the material of the filaments, the desired degree of orientation and the denior of the filaments. Normally, a diameter of from 1 to 5 mm. is advantageous from a view point of preparation, cost and operability. When the diameter of the nozzle 80 is 4mm., there should be twenty-four orifices in the spinneret plate 34 and the total rate of extrusion of the polymer melt should be about 50 g/min. Since the amount of the compressed fluid consumed varies in proportion to the cross-sectional area of the nozzle 80 and the number of filaments, it is uneconomical to make the nozzle 80 of a

large diameter. However, when an extremely small diameter nozzle is used, and a comparatively large number of filaments, the filaments vigorously contact the interior surfaces of the nozzle causing a loss of energy and physical damage to the filaments. It is also possible to change the diameter of the exit nozzle in the direction of ejection. For example a divergent exit nozzle can be used but is difficult to design. Actually, in cases of a divergent exit nozzle having an extending angle of 5° or 10°, as compared with a straight exit nozzle having the same length of flow passage the ejection speed is lower by from 500 to 1,000 m. per minute. It is preferable that the entrance of the exit nozzle 80 has a slight lead radius (r) in order to prevent the filaments from being caught on the edges around the entrance of the nozzle.

Generally, the longer the length L_2 of the flow passage of the nozzle 80, the greater will be the ejecting speed. When the length of the flow passage is extremely long, start-up of spinning becomes difficult but not impossible. For example, when the diameter of the nozzle 80 is 4 mm. and the length of the flow passages 1,000 mm., spinning can be started by aspiration from outside the nozzle 80. A flow passage of from 50 to 300 mm. is preferable.

Upon supplying the compressed fluid there is often a tendency for the spinneret plate to become overcooled which causes breaking of the filaments. This occurs when the temperature of the compressed fluid is low or when the pressure is high. It can be prevented by maintaining the temperature of the spinneret assembly 30 at from 10° to 40° C. higher than the desired temperature of the spinneret. For example, when polyethylene terephthalate is used, the temperature of the spinneret 30 is normally maintained at 280° to 290° C. When the filaments tend to break due to overcooling it is preferable to maintain the temperature at 300°—320° C. since by doing so a stable spinning state is obtained. Alternatively the cylinder 32 may be kept warm by using heated air or steam as the compressed fluid.

Ejectors as in Figures 5 and 7 are effective for preventing fusion of the filaments to one another and for increasing the production efficiency. A distinguishing feature of Figure 7 is that in Figure 7 the upper surface of an exit nozzle 84 is formed in the shape of a funnel. In Figures 5 and 7 L is the distance between the lower surface of the spinneret plate 34 and the upper surface of the exit nozzle 80, 84. There is a distance L_1 between the lower surface of the spinneret plate 34 and the compressed air orifices 40, and a distance L_2 between the orifice 40, and the upper surface of the exit nozzle 80, 84. In Figure 7 the compressed air orifices 40 are in two rows, the central point of which is taken as the position at which the orifices are located.

When conditions shown by oblique lines in Figure 6 are selected when the material is polyethylene terephthalate, it is possible to prepare a non-woven sheet consisting of filaments having a tenacity of at least 3.0 g/d., an elongation of not more than 70% and a shrinkage in boiling water of not more than 5% the latter especially where small denier filaments are concerned.

In Figure 7, the funnel-shape of the upper surface of the nozzle plate 88 is especially effective when breaking of the filaments takes place since the broken ends are easily fed through the exit nozzle 84 and discharged. The funnel shaped surface is highly effective for feeding the ends of the filaments at the time of start-up. If the angle θ of the funnel exceeds 180°, the flow of the compressed fluid inside the cylinder tends to be disrupted. When it is desired to especially reduce the elongation of the filaments, the compressed fluid orifices are located so as to satisfy the following equation

$$L_1 > \frac{L}{2} \text{ and } (L_1 + L_2) = L \qquad \text{(iii)}$$

L being the distance between the lower surface of the spinneret plate and the exit nozzle entrance in the nozzle plate; L_1 being the distance between the lower surface of the spinneret plate and the compressed fluid orifices; and L_2 being the distance between the compressed fluid orifices and the exit nozzle entrance.

An ejector which is especially effective for facilitating the opening of the filaments when the filaments are ejected from the exit nozzle to form a non-woven sheet is shown in Figures 8 and 9. It differs from those so far described in that two exit nozzles 90, 92 are provided in a nozzle plate 94. The spinneret orifices are likewise divided into two groups in the spinneret plate as shown in Figure 9. Figure 9a shows the nozzle plate 94 showing the two nozzles 92, 90 in the right and left positions. Figure 9a′ shows that the spinneret orifices are divided into right and left groups 96 and 98. When the opening of the filaments ejected from the exit nozzle is desired to be facilitated still further, it is advisable to use exit nozzle plates 9b and 9c having three and six nozzles respectively and spinneret plates 9b′ and 9c′.

For facilitating the opening of the filaments, it is advisable to increase the number of exit nozzles. As the number of exit nozzles is increased, the start-up time for feeding the filaments through the nozzles is substantially increased. It is thus disadvan-

tageous to increase the number of exit nozzles at random. By using a nozzle plate having funnel-shaped portions such as that shown in Figure 7, the disadvantages with regard to start-up time may be overcome. When the number of exit nozzles is increased, the degree of orientation of the obtained filaments tends to be higher.

The ejectors having lower sections shown in Figures 10, 11, 12 and 13 are especially useful for making non-woven sheets of a uniform thickness. That in Figure 10 differs with regard to the structure of the lower end surface of the pressure chamber 48. The lower surface of the nozzle plate 100 has a spherical surface and a supporting plate 102 is provided having a swivel seat in which the spherical surface is mounted with a gas tight seal on the lower end surface of the cylinder 32 (figure 11). The exit nozzle plate 100 is freely movable in the swivel seat. In the nozzle plate 100, an exit nozzle 106 is provided. At the lower end of the nozzle 106, an outlet pipe 108 is further provided.

An assembly of four of the ejectors shown in Figure 10 is shown in Figure 12. Each of the outlet pipes 108 is connected to a connecting rod 110. The connecting rod 110 is movable from side to side (structure for the moving of the rod is not shown), causing each outlet pipe 108 and the ejection direction of the filaments from each pipe to be similarly moved. A non-woven sheet 110 which is uniform in thickness is accumulated on a conveyor belt 114. It is also possible to make the motion of the outlet pipes 108 circular. It is possible to dispose each of the ejectors shown in Figure 12, at right angles or oblique to the direction of the movement of the conveyor belt 114.

The ejector part of which is shown in Figure 11 is distinguished in that an exit nozzle plate 116 is formed by a column which is rotatably connected to the supporting plate 118 which is mounted on the lower surface of the cylinder 32. The exit nozzle 120 is oblique to the central axial direction of the exit nozzle plate 116. The nozzle plate 116 is rotated about its central axis whereby the ejection direction of the filaments from the exit nozzle is also rotated.

The ejector part of which is shown in Figure 13 is distinguished in that the lower surface of the exit nozzle plate 122 is lengthened. The length of the flow passage of the exit nozzle 124 is considerably lengthened and the lower end of the exit nozzle 124 is funnel-shaped. At the open end of the funnel-shaped tip a flexible tube 126 is attached. The flexible tube 126 has a smooth interior and is capable of bending freely. A rubber, synthetic resin or metal flexible tube whose interior is coated with a resin such as polytetrafluoroethylene is preferably used. A flexible tube having a length of up to about 2 m. may be used. When the length of the tube 126 is too long, there is tendency for the opening of the filaments to be obstructed.

When the length of the flow passage is especially long and is bent, the filaments are difficult to introduce during start-up. Thus at the starting up of the spinning, slender wires may be inserted into the pressure chamber from the exit nozzle end and the spun filaments fed through the exit nozzles by the wires. The pressure is then gradually raised in the pressure chamber. In an apparatus of the type having an exit nozzle plate which moves relative to the supporting plate a lubricant such as grease is used on the sliding surfaces between the exit nozzle plate and the supporting plate, so that it is possible to move the exit nozzle even under pressure.

The following Examples further illustrate the invention; all parts and percentages being by weight unless otherwise indicated.

Example 1

Apparatus as shown in Figure 3 was employed with a spinneret plate with twenty-four spinneret orifices of 0.25 mm. diameter and a single 5 mm. exit nozzle 44. The distance between the spinneret orifices and the exit nozzle was set at 1,000 mm. Filaments of nylon 6 having a specific viscosity (measured at 25° C. in 1% sulphuric acid solution) of 2.45 and polyethylene terephthalate having a specific viscosity in *o*-chlorophenol at 25° C. (η_{OCP}) of 0.67 were separately spun at the told extrusion rate and compressed air pressures shown in Table 1. Since measurement of the denier of filaments is normally conducted at 25° C. and 65° relative humidity in the case of nylon 6, when the absorption of moisture after spinning is taken into account the true extrusion rate would be 3 to 4% higher than that shown in Table 1.

TABLE 1

Polymer	Total Rate of extrusion (g/min)	Air pressure (atm)	Denier (d)	Ejection speed (m/min)	Tenacity (g/d)	Elongation (%)	Shrinkage in Boiling water (%)
Nylon 6	48	1.0	3.7	4900	3.60	72.5	—
	48	2.0	3.1	5800	3.82	45.2	—
P.E.T.	48	1.0	2.36	7800	1.99	78.2	59.0
	48	2.0	1.58	11400	3.42	70.5	14.0
	48	3.9	1.79	10100	4.14	68.2	2.5

At a position 80 cm. below the exit nozzle plate, a wire mesh conveyor belt was provided to catch and collect the filaments so as to form a non-woven sheet. The filaments which comprises the non-woven sheet were found to be randomly disposed. A synthetic film was then applied to the sheet so as to form a substrate for an artificial leather.

EXAMPLE 2

Apparatus as shown in Figure 7 was employed having twenty-four spinneret orifices 36 of 0.3 mm. diameter and a single exit nozzle 84 of 3 mm. diameter. The pressure of the compressed air was maintained at 3 atm. while feeding approximately 400 litre/min. of air. The distance between the spinneret orifices and the exit nozzle was set at 100 cm. The internal inclined angle θ of the nozzle was 90°. The inner diameter of the pressure chamber was 70 mm. The distance between the spinneret plate and the orifices for the compressed air was selected so as to become 40%, 60% and 80% of the distance between the spinneret plate and the exit nozzle. The total rate of extrusion from the spinnerets was set at 72 g/min. for each value of L_1. Using this apparatus, polyethylene terephthalate was melted at 280° C. and spun into filaments. The results are shown in Table 2.

TABLE 2

L_1 (cm)	40	60	80
Spinnability	Fusion occurred	Good	Good
Elongation (%)	170	91	76
Shrinkage in boiling water (%)	4.3	6.3	3.7

EXAMPLE 3

Apparatus as shown in Figure 8 was employed using an exit nozzle plate having three separate nozzles as is shown in Figure 9b. The number of spinneret orifices used was twenty-four, the diameter of each of the spinneret orifices was 0.5 mm. The diameter of each of the nozzles was 4 mm. The distance between the spinneret plate and the exit nozzle plate was set at 60 cm. The inner diameter of the pressure chamber was 15 cm. At a position slightly lower than the intermediate point between the spinneret plate and the exit nozzle plate, a 5 cm. wide perforated metal strip was provided for introducing the compressed air. The pressure of the compressed air was maintained at 3 atm. and the temperature was held at 30° C. Molten poly-

ethylene terephthalate at 280° C. was extruded from the spinneret orifices at a total extrusion rate of 60 g/min. The filaments ejected from the exit nozzles consisted of a group of filaments of about 8 denier. Overall the filaments had an average tenacity of 3.4 g/d., which was deviated from by a maximum of 16%, a mean elongation of 87%, which was deviated from by a maximum of 17%, and the shrinkage in boiling water of a non-woven sheet formed from the filaments was 2% in the longitudinal direction and 3% in the transverse direction. A 50 cm. wide sheet was caught and collected on a net conveyor and the thickness of the sheet varied by a maximum of 9.6% over its whole length. The weight of the sheet was found to be an average of approximately 100 g/m². The variation in the thickness was obtained by measuring the sheet at 1 cm. intervals using a dial thickness gauge having a contacting portion which consisted of a disc of a 5 mm. diameter.

EXAMPLE 4

Apparatus as shown in Figure 10 was employed having a spinneret plate having twenty-four spinneret orifices of 0.23 mm. diameter and a single 3 mm. diameter exit nozzle. The flow passage of the exit nozzle was set at 100 mm. in length. The distance between the spinneret plate and the exit nozzle was set at 500 mm. Polyethylene terephthalate having an η_{ocp} of 0.60 was extruded from the spinneret at 320° C. at a total rate of 24 g/min. The pressure of the compressed air and the inclined angle of the exit nozzle were as shown in Table 3. The inclined angle of the nozzle is the angle formed by the central axis of the pressure chamber and the central axis of the nozzle.

TABLE 3

Air pressure (atm)	Inclining angle of the nozzle (°)	Ejection speed of the filaments (m/min)	Denier	Tenacity (g/d) Untreated	Tenacity (g/d) Heat Treated (Dry) at 180°C
3.0	0	6640	1.36	3.17	3.34
	10	5900	1.53	2.85	3.39
	20	5000	1.80	2.71	2.77
	30	4850	1.86	3.05	3.06
4.0	0	6380	1.41	3.81	3.67
	10	5980	1.50	3.41	3.52
	20	5510	1.63	3.19	3.28
	30	5050	1.18	3.25	3.30

TABLE 3 (Continued)

Elongation (%)		
Untreated	Heat treated (Dry) at 180°C	Dry Heat shrinkage at 180°C (%)
31.4	34.5	2.5
38.4	44.8	2.5
47.0	48.6	3.0
57.7	59.4	4.7
33.9	33.6	2.1
41.0	45.8	2.9
42.1	49.2	2.8
51.8	52.4	5.1

EXAMPLE 5

In apparatus as shown in Figure 12, six ejectors were arranged at regular intervals in a transverse direction. At a position 600 mm. below the tips of the exit nozzles, a wire screen having seven wires per inch was positioned so as to move at right angles to the ejectors. Connecting rods were secured respectively so as to cause an oscillation motion at a ratio of one reciprocation per second at an angle of ±5° at right angles to the conveyor. The filaments from the respective exit nozzles were caught and collected on the net conveyor to form a non-woven sheet. In each of said devices, the number of spinneret orifices was twenty-four and the diameter of the spinneret orifices was 0.23 mm. The diameter of the exit nozzles was 3 mm. The length of the flow passage of the exit nozzle and the distance between the spinneret orifices and the exit nozzle was made 500 mm. Polyethylene terephthalate (η_{OCP} 0.69) was discharged from the spinnerets at a total rate of extrusion per spinneret of 24 g/min. and a temperature of 320° C. On the under side of the net conveyor, a suction box having 100 mm. × 1800 mm. opened surface was provided and the non-woven sheet was drawn down by the suction plate. The transfer speed of the conveyor was set at 80 cm./min. A sheet of about 100 g./m.^{2} was obtained having a uniform thickness over a width of about 170 cm. By subjecting this sheet to treatments with an adhesive, a non-woven sheet was obtained, consisting of continuous filaments, having a tensile strength of 3—4 kg. per sq. cm.

EXAMPLE 6

Apparatus as shown in Figure 13 was employed having twenty-four spinneret orifices each of 0.25 mm. diameter, an exit nozzle of 4 mm. diameter and a flow passage length set at 10 cm. The diameter of the flexible tube was 40 mm. The length of the flexible tube was 20 cm. The distance between the spinneret orifices and the exit nozzle was 50 cm. Polyethylene terephthalate (η_{OCP} 0.68) was extruded at a total rate of extrusion of 24 g./min. and a temperature of 320° C. The characteristics of the filaments obtained are shown in Table 4.

TABLE 4

Air pressure (atg)	Radius of curvature of the flexible tube (mm)	Ejection speed (m/min)	Denier	Tenacity (g/d)	Elongation (%)	Shrinkage in boiling water (%)
2.0		7050	1.28	4.21	40.5	1.6
"	600	4420	2.04	3.26	57.4	5.5
"	450	4080	2.21	1.78	50.1	4.1
"	300	3690	2.44	2.81	78.1	10.1
3.0		6720	1.34	3.69	43.8	1.8
"	600	4810	1.87	3.16	61.4	6.2
"	450	4120	2.19	3.48	62.1	5.8
"	300	3700	2.43	3.12	70.9	9.0
4.0		6310	1.43	3.46	44.6	2.4
"	600	4180	2.15	3.10	66.2	4.2
"	450	3720	2.42	3.28	70.5	8.9
"	300	3480	2.59	2.92	72.9	14.2

WHAT WE CLAIM IS:—

1. A process for the manufacture of continuous filaments from a synthetic polymer melt comprising hot-melt extruding the polymer into a pressurized chamber and introducing a pressurized fluid into the chamber for cooling and solidifying the filaments and for ejecting them from the chamber through an exit nozzle, the rate of extrusion per filament being:

$$1.5L+0.05<M\leqslant 5.5L+2.25$$
$$L\geqslant 0.30$$

wherein L is the distance between the spinneret orifice and the exit nozzle in meters and M is the extrusion rate of the polymer per spinneret orifice in grams per minute.

2. A process according to claim 1 in which the length of the flow passage of the exit nozzle is at least 20 mm.

3. An ejector when used for the manufacture of continuous filaments from synthetic polymer melts in a process according to claim 1 or claim 2 comprising a hot-melt extruder leading into a pressurised chamber having a distributor for the introduction of pressurized fluid for cooling and solidifying the filaments and ejecting them through one or more exit nozzles in the chamber, the nozzle or nozzles being movable relative to the chamber.

4. An ejector according to claim 3 in which the exit nozzle or nozzles have a spherical outer form and are rotatably mounted in a spherical seat whereby the direction of the nozzle or nozzles may be adjusted.

5. An ejector according to claim 3 in which the exit nozzle or nozzles have a cylindrical outer form and are rotatably mounted, the axis of the nozzle or nozzles being oblique to the axis of rotation, whereby the direction of the nozzle or nozzles may be adjusted.

6. An ejector according to any of claims 3 to 5 in which a flexible tube is secured to the outer end of the exit nozzle or nozzles.

7. A process for the manufacture of continuous filaments of synthetic polymer melts as described in any of the Examples.

ERIC POTTER & CLARKSON,
Chartered Patent Agents,
25 The Crescent,
Leicester.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1972.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1285381 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

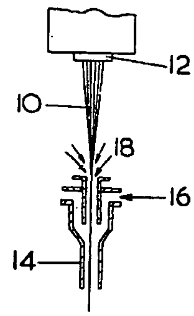


FIG.1.

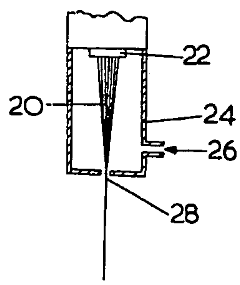


FIG.2.

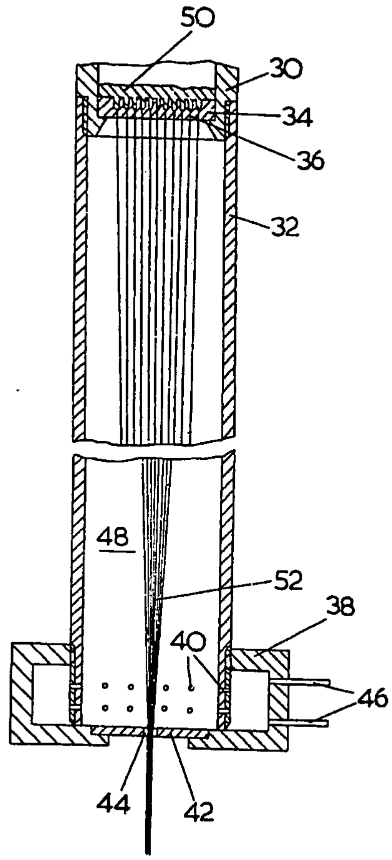


FIG.3.

1285381 COMPLETE SPECIFICATION

4 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 2

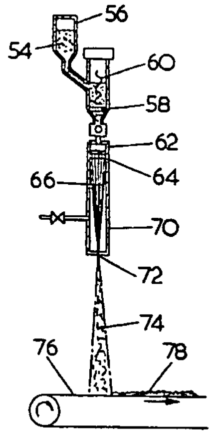


FIG.4.

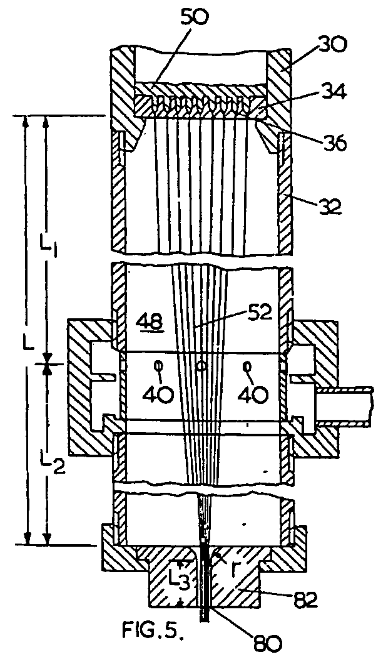


FIG.5.

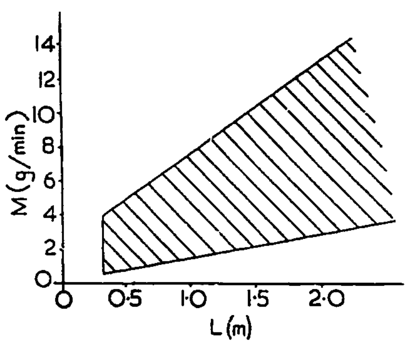


FIG. 6

1285381 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

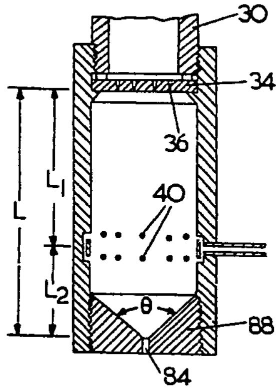


FIG.7.

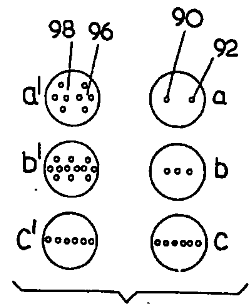


FIG.9.

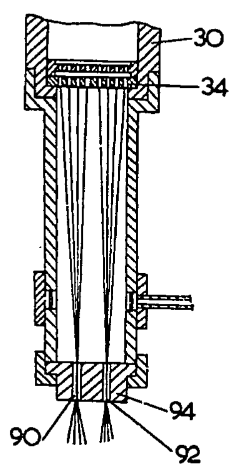


FIG.8.

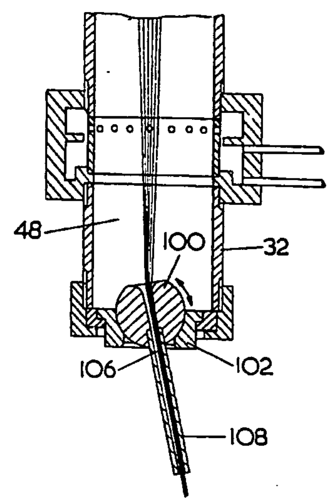


FIG.10.

1285381 COMPLETE SPECIFICATION

4 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 4

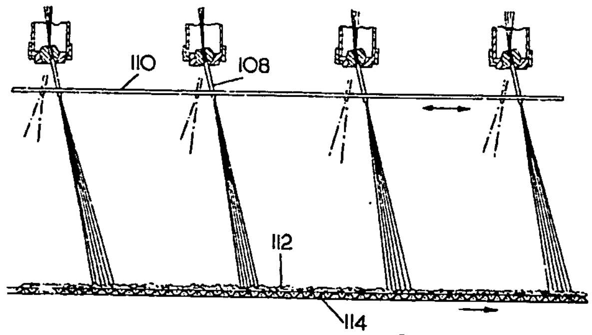
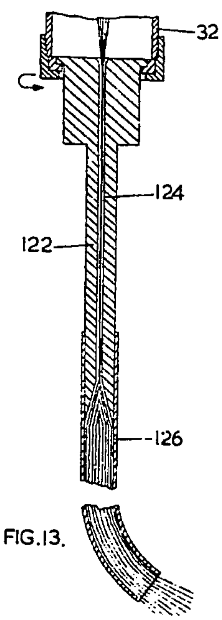


FIG.12.



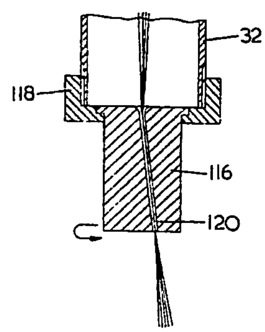


FIG.11.

FIG.13.